Claims:

1. A method in a spread spectrum receiver for narrow-band interference rejection in a received signal transmitted by a spread spectrum transmitter, comprising:

transforming the received signal to a frequency domain signal and identifying narrow-band interference components in the frequency domain signal;

suppressing the identified narrow-band interference components by excising the identified narrow-band interference components from the frequency domain signal to produce an interference excised signal in the frequency domain, and storing in a memory frequencies corresponding to the identified narrow-band interference components;

synchronizing a receiver code to a transmitter code in the frequency domain using the interference excised signal;

generating coefficients for a time domain filter that includes notches at the frequencies corresponding to the excised narrow-band interference components and that jointly despreads and rejects narrow-band interference from said excised frequencies; and

applying the coefficients generated in the preceding step to the time domain filter; and despreading and filtering in real time in the time domain the received signal using the applied coefficients.

2. The method of claim 1 further comprising:

repeatedly performing at predetermined intervals said transforming, suppressing, coefficient generating and coefficient applying steps, whereby filtering by the time domain filter follows interfering signals of varying frequencies.

3. The method of claim 1, wherein:

said transforming step comprises,

sampling a received signal at K samples per chip for a duration of M code periods,

applying a data tapering window of M code periods to the sampled received signal to produce a windowed signal, and

Fourier transforming the windowed signal and producing a set of Fourier transform output points; and

said suppressing step comprises,

excising points from said set of Fourier transform output points that exceed the remaining points by a predetermined threshold.

4. The method of claim 1, wherein:

said synchronizing step comprises,

determining a code delay and a frequency error between the transmitter and the receiver; and

said coefficient generating step uses the frequency error in generating said coefficients and said despreading and filtering step uses the code delay in despreading and filtering.

5. The method of claim 3 further comprising:

decimating said set of Fourier transform output points by a factor of M.

6. The method of claim 3 further comprising:

filtering said set of Fourier transform output points in a filter having a bandwidth corresponding to a chip rate of said spreading code by retaining 1/K of the output points centered on zero Hertz and zeroing the other points.

7. The method of claim 3 further comprising:

frequency shifting said excised set of Fourier transform output points by an amount sufficient to cancel an intermediate frequency.

8. The method of claim 1, wherein:

said generating coefficients step comprises,

Fourier transforming M periods of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

complex conjugating the Fourier transformed code signal to produce a reference code,

suppressing narrow-band interference by excising from the reference code the stored frequencies corresponding to the identified narrow-band interference components,

inverse Fourier transforming the excised reference code, and

applying a data tapering window of M code periods to the inverse Fourier transformed excised reference code to produce said coefficients.

9. The method of claim 8, wherein:

said synchronizing step comprises determining a code delay and a frequency error between the transmitter and the receiver; and

said coefficient generating step removes a frequency error between the transmitter and the receiver by shifting said reference code an amount sufficient to cancel the frequency error.

10. The method of claim 8, wherein:

said generating coefficients step comprises,

Fourier transforming one period of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

complex conjugating the Fourier transformed code signal to produce a reference code,

suppressing narrow-band interference by excising from the reference code the stored frequencies corresponding to the identified narrow-band interference components,

upsampling the excised reference code by a factor of M corresponding to the number of code periods,

inverse Fourier transforming the upsampled excised reference code, and

applying a data tapering window of M code periods to the inverse Fourier transformed upsampled excised reference code to produce said coefficients.

11. The method of claim 8, further comprising:

filtering said reference code in a filter having a bandwidth corresponding to a chip rate of said spreading code by retaining 1/K of the reference code and zeroing the remainder of the reference code; and

zero padding said excised reference code by a factor K-1 prior to performing said inverse Fourier transforming step.

12. The method of claim 8, further comprising,

frequency shifting said reference code by an amount sufficient to cancel an intermediate frequency.

13. The method of claim 1, wherein:

said despreading and filtering step comprises,

sampling a received signal at K samples per chip for a duration of M code periods,

matched filtering the signal samples using the applied coefficients to produce output samples at a message symbol rate, and

IIR filtering the output samples to cancel message intersymbol interference generated in the matched filter.

14. A method in a spread spectrum receiver for narrow-band interference rejection in a received signal transmitted by a spread spectrum transmitter, comprising:

transforming the received signal to a frequency domain signal and identifying narrow-band interference components in the frequency domain signal;

suppressing the identified narrow-band interference components by excising the identified narrow-band interference components from the frequency domain signal to produce an interference excised signal in the frequency domain, and storing in a memory frequencies corresponding to the identified narrow-band interference components;

synchronizing a receiver code to a transmitter code in the frequency domain using said interference excised signal; and

despreading and filtering in real time in the frequency domain the received signal, comprising transforming the received signal received after synchronization to a post-synchronization frequency domain signal and identifying post-synchronization narrow-band interference components in the frequency domain signal, suppressing the identified post-synchronization narrow-band interference components by excising the identified post-synchronization narrow-band interference components from the post-synchronization frequency domain signal to produce a post-synchronization interference excised signal in the frequency domain, and despreading the post-synchronization interference excised signal, whereby filtering in the frequency domain follows interfering signals of varying frequencies.

15. The method of claim 14, wherein:

said transforming step comprises,

sampling a received signal at K samples per chip for a duration of M code periods,

applying a data tapering window of M code periods to the sampled received signal to produce a windowed signal, and

Fourier transforming the windowed signal and producing a set of Fourier transform output points; and

said suppressing step comprises excising points from said set of Fourier transform output points that exceed the remaining points by a predetermined threshold.

16. The method of claim 14, wherein:

said synchronizing step comprises determining a code delay and a frequency error between the transmitter and the receiver; and

said despreading and filtering step uses the frequency error and the code delay in despreading and filtering.

17. The method of claim 15 further comprising:

decimating said set of Fourier transform output points by a factor of M.

18. The method of claim 15 further comprising:

filtering said set of Fourier transform output points in a filter having a bandwidth corresponding to a chip rate of said spreading code by retaining 1/K of the output points centered on zero Hertz and zeroing the other points.

19. The method of claim 15 further comprising:

frequency shifting said excised set of Fourier transform output points by an amount sufficient to cancel an intermediate frequency.

20. The method of claim 14, wherein:

said despreading and filtering step comprises:

Fourier transforming M periods of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

complex conjugating the Fourier transformed code signal to produce a reference code,

sampling a received signal at K samples per chip for a duration of M code periods,

applying a data tapering window of M code periods to the signal samples,

Fourier transforming the windowed signal and producing a set of Fourier transform output points,

suppressing narrow-band interference by excising the set of Fourier transform output points that exceed the remaining points by a predetermined threshold,

multiplying the excised set of Fourier transform output points by the reference code and producing an output data set,

summing the output data set and producing an output sample at the message symbol rate, and

IIR filtering the output samples to cancel message intersymbol interference generated by the multiplying and summing.

21. The method of claim 20, wherein:

said synchronizing step comprises determining a code delay and a frequency error between the transmitter and the receiver; and

said despreading and filtering step comprises removing a frequency error between the

transmitter and the receiver by shifting said excised set of Fourier transform output points an amount sufficient to cancel the frequency error.

22. The method of claim 20, wherein:

said despreading and filtering step comprises:

Fourier transforming one period of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

complex conjugating the Fourier transformed code signal to produce a reference code,

sampling a received signal at K samples per chip for a duration of M code periods,

applying a data tapering window of M code periods to the signal samples,

Fourier transforming the windowed signal and producing a set of Fourier transform output points,

decimating the set of Fourier transform output points by a factor of M,

suppressing narrow-band interference by excising the downsampled set of Fourier transform output points that exceed the remaining points by a predetermined threshold,

multiplying the excised set of Fourier transform output points by the reference code and producing an output data set,

summing the output data set and producing an output sample at the message symbol rate, and

IIR filtering the output samples to cancel message intersymbol interference generated by the multiplying and summing.

23. The method of claim 20, further comprising:

filtering said reference code in a filter having a bandwidth corresponding to a chip rate of said spreading code by retaining 1/K of the reference code and zeroing the remainder of the reference code; and

filtering said set of Fourier transform output points in a filter having a bandwidth corresponding to a chip rate of said spreading code by retaining 1/K of the output points centered on zero Hertz and zeroing the other points.

24. The method of claim 20, further comprising:

frequency shifting said excised set of Fourier transform output points by an amount sufficient to cancel an intermediate frequency;

25. A narrow-band interference rejecting spread spectrum receiver configured to receive a signal transmitted by a spread spectrum transmitter, comprising:

a transform mechanism configured to convert the received time domain signal to a frequency domain signal and to identify narrow-band interference components in the frequency domain signal;

an interference suppression mechanism configured to excise the identified narrow-band interference components from the frequency domain signal, to produce an interference excised signal in the frequency domain, and to store in a memory frequencies corresponding to the excised interference components;

a synchronizer configured to operate in the frequency domain to align a receiver code to a transmitter code using the interference excised signal;

a coefficient generator configured to generate coefficients for a time domain filter that includes notches at the frequencies corresponding to the excised narrow-band interference components and that jointly despreads and rejects narrow-band interference from said excised frequencies; and

a time domain filter coupled to the coefficient generator and having applied thereto the coefficients generated by the coefficient generator, said time domain filter configured to despread and filter in real time a received signal upon alignment of the receiver code to the transmitter code by the synchronizer.

26. The receiver of claim 25, further comprising:

a processor configured to control the transform mechanism, the interference suppressor, and the coefficient generator to operate repeatedly at predetermined intervals, whereby the time domain filter follows interfering signals of varying frequencies.

27. The receiver of claim 25, wherein:

said transform mechanism comprises,

a sampler configured to sample a received signal at K samples per chip for a duration of M code periods,

a windowing mechanism configured to apply a data tapering window of M code periods to the sampled received signal to produce a windowed signal, and

a Fourier transform mechanism configured to perform a Fourier transform of the windowed signal to produce a set of Fourier transform output points; and

said suppression mechanism comprises,

an excising mechanism configured to set to zero points from said set of Fourier transform output points that exceed the remaining points by a predetermined threshold.

28. The receiver of claim 25, wherein:

said synchronizer comprises a resolver mechanism configured to determine a code delay and a frequency error between the transmitter and the receiver; and

said coefficient generator uses the frequency error in generating said coefficients and said time domain filter uses the code delay in despreading and filtering.

29. The receiver of claim 27, further comprising:

a downsampler configured to downsample said set of Fourier transform output points by a factor of M.

30. The receiver of claim 27, further comprising:

a filter configured to filter the set of Fourier transform output points, said filter having a bandwidth corresponding to a chip rate of said spreading code and configured to retain 1/K of the Fourier transform output points centered on zero Hertz and to set to zero the other Fourier transform output points.

31. The receiver of claim 27, further comprising:

a frequency shifter configured to shift the frequency of the excised set of Fourier transform output points by an amount sufficient to cancel an intermediate frequency.

32. The receiver of claim 25, wherein:

said coefficient generator comprises,

a Fourier transform mechanism configured to produce a Fourier transform of M periods of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

a complex conjugating mechanism configured to perform a complex conjugate of the Fourier transformed code signal to produce a reference code,

a narrow-band interference suppression mechanism configured to excise from the reference code the frequencies stored in the memory and corresponding to the identified narrow-band interference components,

an inverse Fourier transform mechanism configured to perform an inverse Fourier

transform of the excised reference code, and

a windowing mechanism configured to apply a data tapering window of M code periods to the inverse Fourier transformed excised reference code to produce said coefficients.

33. The receiver of claim 32, wherein:

said synchronizer comprises a resolver mechanism configured to determine a code delay and a frequency error between the transmitter and the receiver; and

said coefficient generator is configured to remove a frequency error between the transmitter and the receiver by shifting said reference code an amount sufficient to cancel the frequency error.

34. The receiver of claim 32, wherein:

said coefficient generator comprises,

a Fourier transform mechanism configured to perform a Fourier transform of one period of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

a complex conjugate mechanism configured to perform a complex conjugate of the Fourier transformed code signal to produce a reference code,

a narrow-band interference suppression mechanism configured to excise from the reference code the frequencies corresponding to the identified narrow-band interference components stored in the memory,

an upsampling mechanism configured to upsample the excised reference code by a factor of M corresponding to the number of code periods to produce an upsampled excised reference code,

an inverse Fourier transform mechanism configured to perform an inverse Fourier transform of the excised reference code, and

a windowing mechanism configured to apply a data tapering window of M code periods to the inverse Fourier transformed upsampled excised reference code to produce said coefficients.

35. The receiver of claim 32, further comprising:

a filter configured to filter said reference code, said filter having a bandwidth corresponding to a chip rate of said spreading code and configured to retain 1/K of the reference code and to set to zero the remainder of the reference code; and

a zero padder mechanism configured to zero pad said excised reference code by a factor K-1 prior to said inverse Fourier transform.

36. The receiver of claim 32, further comprising,

a frequency shifter configured to shift the frequency of the reference code by an amount sufficient to cancel an intermediate frequency.

37. The receiver of claim 25, wherein:

said time domain filter comprises,

a sampler configured to sample a received signal at K samples per chip for a duration of M code periods,

a matched filter configured to filter the sampled received signal using the applied coefficients to produce output samples at a data symbol rate, and

an IIR filter configured to filter the output samples to cancel message intersymbol interference generated in the matched filter.

38. A narrow-band interference rejecting spread spectrum receiver configured to receive a signal transmitted by a spread spectrum transmitter, comprising:

a first transform mechanism configured to convert the received time domain signal to a frequency domain signal and to identify narrow-band interference components in the frequency domain signal;

an interference suppression mechanism configured to excise the identified narrow-band interference components from the frequency domain signal to produce an interference excised signal in the frequency domain;

a synchronizer configured to operate in the frequency domain to align a receiver code to a transmitter code using the interference excised signal; and

a despreader and filter mechanism configured to operate in real time in the frequency domain on the received signal, comprising a second transform mechanism configured to transform the received signal received after synchronization to a post-synchronization frequency domain signal and to identify post-synchronization narrow-band interference components in the frequency domain signal, a suppression mechanism configured to excise the identified post-synchronization narrow-band interference components from the post-synchronization frequency domain signal to produce a post-synchronization interference excised signal in the frequency domain, and a despreader of the post-synchronization interference excised signal, whereby the

frequency domain filter follows interfering signals of varying frequencies.

39. The receiver of claim 38, wherein:

said first transform mechanism comprises,

a sampling mechanism configured to sample the received signal at K samples per chip for a duration of M code periods,

a windowing mechanism configured to apply a data tapering window of M code periods to the sampled received signal to produce a windowed signal, and

a Fourier transform mechanism configured to perform a Fourier transform of the windowed signal to produce a set of Fourier transform output points; and

said suppression mechanism comprises,

an excising mechanism configured to set to zero points from said set of Fourier transform output points that exceed the remaining points by a predetermined threshold.

40. The receiver of claim 38, wherein:

said synchronizer comprises a resolver mechanism configured to determine a code delay and a frequency error between the transmitter and the receiver;

said coefficient generator is configured to use the frequency error in generating said coefficients; and

said despreader and filter mechanism is configured to use the code delay in despreading and filtering.

41. The receiver of claim 39, further comprising:

a downsampler configured to downsample said set of Fourier transform output points by a factor of M.

42. The receiver of claim 39, further comprising:

a filter configured to filter the set of Fourier transform output points, said filter having a bandwidth corresponding to a chip rate of said spreading code and configured to retain 1/K of the Fourier transform output points centered on zero Hertz and to set to zero the other Fourier transform output points.

43. The receiver of claim 39 further comprising:

a frequency shifter configured to shift the frequency of the excised set of Fourier transform output points by an amount sufficient to cancel an intermediate frequency.

44. The receiver of claim 38, wherein:

said despreader and filter mechanism comprises:

a Fourier transform configured to perform a Fourier transform of M periods of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

a complex conjugate mechanism configured to perform a complex conjugate of the Fourier transformed code signal to produce a reference code,

a sampler mechanism configured to sample the received signal at K samples per chip for a duration of M code periods,

a windowing mechanism configured to apply a data tapering window of M code periods to the received signal samples to produce a windowed signal,

a Fourier transform mechanism configured to perform a Fourier transform of the windowed signal to produce a set of Fourier transform output points,

a narrow-band interference suppression mechanism configured to excise the set of Fourier transform output points of output points that exceed the remaining output points by a predetermined threshold,

a mechanism configured to produce a product of the excised set of Fourier transform output points and the reference code to produce an output data set,

a summing mechanism configured to perform a summation of the output data set to produce an output sample, and

an IIR filter configured to filter the output sample to cancel message intersymbol interference generated by the product and summation.

45. The receiver of claim 44, wherein:

said synchronizer comprises a resolver mechanism configured to determine a code delay and a frequency error between the transmitter and the receiver; and

said despreader and filter mechanism is configured to remove a frequency error between the transmitter and the receiver by shifting said excised set of Fourier transform output points an amount sufficient to cancel the frequency error.

46. The receiver of claim 44, wherein:

said despreader and filter mechanism comprises:

a Fourier transform mechanism configured to perform a Fourier transform of one period

of a spreading code at K samples per chip to produce a Fourier transformed code signal, the spreading code being the same as used at the transmitter to form the transmitted spread spectrum signal received by said receiver,

a complex conjugate mechanism configured to perform a complex conjugate of the Fourier transformed code signal to produce a reference code,

a sampler mechanism configured to sample the received signal at K samples per chip for a duration of M code periods,

a windowing mechanism configured to apply a data tapering window of M code periods to the signal samples to produce a windowed signal,

a Fourier transform mechanism configured to perform a Fourier transform of the windowed signal to produce a set of Fourier transform output points,

a downsampler configured to downsample the set of Fourier transform output points by a factor of M,

a narrow-band interference suppression mechanism configured to excise from the downsampled set of Fourier transform output points those output points that exceed the remaining points by a predetermined threshold,

a mechanism configured to produce a product of the excised set of Fourier transform output points and the reference code to produce an output data set,

a summing mechanism configured to perform a summation of the output data set to produce an output sample, and

an IIR filter configured to filter the output sample to cancel message intersymbol interference generated by the product and summation.

47. The receiver of claim 44 further comprising:

a filter configured to filter the reference code, said filter having a bandwidth corresponding to a chip rate of said spreading code and configured to retain 1/K of the reference code and to set to zero the remainder of the reference code; and

a filter configured to filter said set of Fourier transform output points, said filter having a bandwidth corresponding to a chip rate of said spreading code and configured to retain 1/K of the output points centered on zero Hertz and to set to zero the other points Fourier transform output points.

48. The receiver of claim 44 further comprising:

a frequency shifter configured to shift the frequency of said excised set of Fourier transform output points by an amount sufficient to cancel an intermediate frequency.

49. A narrow-band interference rejecting device in a spread spectrum receiver, comprising:

means for transforming a received spread spectrum signal to a frequency domain signal and identifying narrow-band interference components in the frequency domain signal;

means for suppressing the identified narrow-band interference components by excising the identified narrow-band interference components from the frequency domain signal to produce an interference excised signal in the frequency domain, and means for storing in a memory frequencies corresponding to the identified narrow-band interference components;

means for synchronizing a receiver code to a transmitter code in the frequency domain using the interference excised signal;

means for generating coefficients defining filter notches at the frequencies corresponding to the excised narrow-band interference components and defining a despreading function; and

means for despreading and filtering in real time in the time domain the received signal using the coefficients generated by said means for generating coefficients.

50. The receiver of claim 49, further comprising:

means for controlling said transforming means, said suppressing means and said coefficent generating means to operate repeatedly at predetermined time intervals so that said means for despreading and filtering follows interfering signals of varying frequencies.

51. A narrow-band interference rejecting device in a spread spectrum receiver, comprising:

means for transforming a received spread spectrum signal to a frequency domain signal and identifying narrow-band interference components in the frequency domain signal;

means for suppressing the identified narrow-band interference components by excising the identified narrow-band interference components from the frequency domain signal to produce an interference excised signal in the frequency domain, and means for storing in a memory frequencies corresponding to the identified narrow-band interference components;

means for synchronizing a receiver code to a transmitter code in the frequency domain using said interference excised signal; and

means for despreading and filtering in real time in the frequency domain the received signal, comprising means for transforming the received signal received after synchronization to a post-synchronization frequency domain signal and identifying post-synchronization narrow-band interference components in the frequency domain signal, means for suppressing the identified post-synchronization narrow-band interference components by excising the identified post-synchronization narrow-band interference components from the post-synchronization frequency domain signal to produce a post-synchronization interference excised signal in the frequency domain, and means for filtering and despreading the post-synchronization interference excised signal in the frequency domain so that filtering in frequency domain follows interfering signals of varying frequencies.

52. A computer program product configured to store computer code for implementing the method of any one of Claims 1-24.